ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΙΑΣ

ΤΜΗΜΑ ΕΠΙΣΤΗΜΗΣ ΦΥΣΙΚΗΣ ΑΓΩΓΗΣ ΚΑΙ ΑΘΛΗΤΙΣΜΟΥ

«Η ΕΠΙΔΡΑΣΗ ΤΗΣ ΜΕΤΡΗΣΗΣ ΤΟΥ ΟΙΔΗΜΑΤΟΣ ΤΗΣ ΠΟΔΟΚΝΗΜΙΚΗΣ ΣΤΗ ΒΕΛΤΙΩΣΗ ΤΗΣ ΑΞΙΟΠΙΣΤΙΑΣ ΤΟΥ ΠΡΩΤΟΚΟΛΛΟΥ OTTAWA ANKLE RULES»

του

Ιωάννη Νικολάου Σπανού

Επιβλέπων Καθηγητής
Γιάκας Ιωάννης

Μεταπτυχιακή Διατριβή που υποβάλλεται στο καθηγητικό σώμα για τη μερική εκπλήρωση των υποχρεώσεων απόκτησης του μεταπτυχιακού τίτλου του Προγράμματος Μεταπτυχιακών Σπουδών «Άσκηση και Υγεία» του Τμήματος Επιστήμης Φυσικής Αγωγής και Αθλητισμού του Πανεπιστημίου Θεσσαλίας.

Έγκριση τριμελούς συμβουλευτικής επιτροπής:

1. Γιάκας Ιωάννης
2. Τσιόκανος Αθανάσιος
3. Χατζηγεωργιάδης Αντώνιος

Έτος ολοκλήρωσης της διατριβής

2012

UNIVERSITY OF THESSALY

DEPARTMENT OF PHYSICAL EDUCATION AND SPORT SCIENCE

«THE INFLUENCE OF THE MEASUREMENT OF ANKLE EDEMA IN IMPROVING THE RELIABILITY OF THE OTTAWA ANKLE RULES PROTOCOL»

Ioannis N. Spanos

Supervising Professor
Giannis Giakas

2012

Ή κανείς ή κι οί δύο μαζί,μ'ακούς ;

"Το Μονόγραμμα" - Οδυσσέας Ελύτης

στη Δήμητρα

Table of contents

ABSTRACT

Objectives: To validate the accuracy of the Ottawa Ankle Rule (OAR) to rule out clinical significant ankle fractures and to evaluate the impact of measuring ankle edema, with the figure of eight method, in patients with ankle injuries examined in the emergency department of an average Greek hospital.

Design: prospective cohort study.

Participants: between January and February 2012 123 patients presented with a case of ankle injury. Of these, 119 patients both met recruitment criteria and provided data for this study. Resident orthopaedic surgeons examined the patients and filled the data form and all patients underwent blinded radiographic assessment.

Main outcome measures: sensitivity, specificity

Results: of the 119 patients with ankle sprains 34 had an ankle fracture (28,6%). All cases with a fracture had difference in the edema measurement between the injured and the uninjured ankle >1cm (sensitivity 100%) and of 85 patients without a fracture, the edema was ≤1cm in 63 cases (specificity 74,11%). In the same group of patients the OAR missed to predict 2 fractures (sensitivity 94,12%) and showed relative low specificity (37,65%).

Conclusions: this validation study of the OAR in a Greek setting produced similar results than those published previously in various other settings. A new rule, ankle edema measurement, seemed to be more accurate and more specific than OAR in ruling out possible fractures. Further studies should be performed in order to establish this rule in clinical practice.

Key words: ankle injuries; Ottawa ankle rule; figure of eight; ankle edema measurement; sensitivity; specificity; clinical decision rules

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

OBJECTIVES

The study aims to evaluate the impact of measuring ankle edema in improving the accuracy of the Ottawa Ankle Rules method to diagnose clinically significant fractures in patients with ankle injuries examined in the emergency department of a Greek hospital.

IMPORTANCE OF THE STUDY

The implementation of the Ottawa Ankle Rule can prevent needless x-ray exams for ankle injuries whenever there is no chance of fracture, resulting in reduction of examination cost and avoidance of unnecessary exposure to radiation for the patient. The measurement of ankle edema, by improving the diagnostic accuracy of the OAR, can lead to further reduction in the execution of unnecessary radiographs.

EPIDEMIOLOGY

Fractures and dislocations of the ankle and foot are among the most common injuries in the musculoskeletal system. Five to ten million ankle injuries occur each year in the United States (Birrer, Fani-Salek, Totten, Herman, & Politi, 1999), accounting for 36% of all lower limb injuries (Lambers, Ootes, & Ring, 2012) and representing 10% of emergency room visits (Cass & Morrey, 1984). The prevalence and severity of ankle injuries has been increasing since the 1950s, and this has been attributed to the increase in recreational activity

(Birrer, et al., 1999). Ankle sprains are considered to be one of the most common injuries experienced during sport and exercise (Beynnon, Murphy, & Alosa, 2002; Garrick & Requa, 1988; Yeung, Chan, So, & Yuan, 1994). Lesions of the ankle and foot can alter the mechanics of gait and as a result cause stress on other lower limb joints. The disability and time away from occupation resulting from these injuries warrant close attention to diagnosis and management (Anandacoomarasamy & Barnsley, 2005; Beynnon, Vacek, Murphy, Alosa, & Paller, 2005; Cooke et al., 2009; Gerber, Williams, Scoville, Arciero, & Taylor, 1998; Konradsen, Bech, Ehrenbjerg, & Nickelsen, 2002).

ANATOMY

The ankle joint is a ginglymus joint; it includes the tibia, fibula and talus. The structure of the ankle is that of a bony mortise. Ankle’s bounds are medially the malleolar process at the distal end of the tibia, superiorly the flat surface of the distal end of the tibia (the tibial plafond), and laterally the malleolar process of the distal end of the fibula. The smaller lateral malleolus extends distally and posteriorly relative to the medial malleolus. As a result, the transmalleolar axis is externally rotated approximately 15 degrees to the coronal axis of the leg. The mortise is deepened anteriorly by the anterior tibiofibular ligament and buttressed posteriorly by the posterior malleolus and the posterior tibiofibular ligament.

Within this mortise is set the body of the talus. The talus articulates with the tibial plafond by its large superior convexity (the dome). The dome of the talus is wider anteriorly than it is posteriorly. As such, the talus becomes firmly wedged within the ankle mortise on dorsiflexion. This creates medial–lateral tension across the distal tibiofibular syndesmosis and ligament. The intact ankle mortise primarily allows the talus a single plane of motion (flexion–extension), with only a modest amount of anterior–posterior glide. Therefore, this increased stability of the ankle during dorsiflexion affords the means to isolate and assess medial–lateral ankle ligament integrity and subtalar inversion–eversion mobility.

The talus also presents an articular surface to each of the malleoli. It is stabilized within the ankle mortise by the medial and lateral malleoli. Medially, the deltoid ligament forms a dense supporting structure (Figure 1). The deltoid ligament is a triangle-shaped ligament with the apex at the medial malleolus and with fibers extending to the calcaneus, talus, and navicular. The ligament is divided into superficial and deep components. The superficial component has three parts, extending anteriorly to the navicular, inferiorly to the sustentaculum, and posteriorly on the talar body. The deep deltoid ligament extends in two bands from the medial malleolus to the talar body just inferior to the medial facet.

Figure 1 Medial ankle ligament

The ligament support on the lateral aspect is provided by three separate ligamentous bands, the anterior and posterior talofibular ligament and the calcaneofibular ligament (Figure 2). The anterior talofibular ligament (ATFL) extends from the anterior aspect of the distal fibula to the body of the talus. Strain in the ATFL increases with plantar flexion, inversion, and internal rotation. The calcaneofibular ligament (CFL) extends from the tip of the fibula posterior to its insertion on the lateral wall of the calcaneus. It runs deep to the peroneal tendons and crosses the subtalar joint. The CFL is under increased strain with dorsiflexion and inversion. The posterior talofibular ligament (PTFL) originates broadly at the posterior fibula and inserts mainly at the posterolateral tubercle of the talus. It is a broad, strong ligament that is congruous with the posterior capsule of the ankle and subtalar joint.

Figure 2 Lateral ankle ligaments

The anterior talofibular ligament is taut with the ankle joint in plantar flexion, when it is in line with the fibula and is injured most frequently because most injuries occur with the ankle joint in plantar flexion. The calcaneofibular ligament is taut with the ankle joint in dorsiflexion, when the ligament is in line with the fibula. Isolated injuries to the calcaneofibular ligament are less frequent. These injuries occur with the ankle joint in dorsiflexion.

MOTIONS OF THE FOOT & ANKLE

The motions that occur at the ankle joint are plantar flexion and dorsiflexion. During the walking cycle, rapid plantar flexion starts at heel strike and ends by foot flat, after which progressive dorsiflexion occurs. Dorsiflexion reaches a maximum at 40% during walking, when plantar flexion begins, and continues until toe-off, when dorsiflexion occurs again.

The force applied across the ankle joint during walking has been measured at approximately 5 times body weight (Birrer, et al., 1999). This maximum stress occurs just before and just after the onset of plantar flexion of the ankle joint. If this force were extrapolated to running, in which the force is approximately 2 to 2.5 times greater than that of walking, we would see stress across the ankle joint that approaches 10 times body weight (Jesse C. DeLee MD, 2003).

The motions which occur in the subtalar joint are inversion (varus) and eversion (valgus), respectively.

Pronation and supination are complex movements that implicate ankle, subtalar and tarsal joints. Pronation refers to dorsiflexion of the ankle joint, eversion of the subtalar joint, and abduction of the transverse tarsal joint. Supination is the opposite, plantar flexion of the ankle joint, inversion of the subtalar joint, and adduction of the transverse tarsal joint.

ETIOLOGY OF INJURY TO THE FOOT AND ANKLE

The etiology of injury to the foot and ankle is a primary concern because prevention of injury requires the ability to recognize those conditions that are responsible for injury. Research has shown that when etiologic factors are addressed directly, it is possible to alter injury rates. Injury variables can be divided into intrinsic and extrinsic factors. Intrinsic factors include the patient’s individual physical characteristics. These physical characteristics include such things as age, sex, physical fitness, flexibility, varus or valgus malalignment, body weight and previous injury (Beynnon, et al., 2005).

Extrinsic factors, on the other hand, are falls, direct blows and sports activity. The type of sports activity, the environmental conditions, the playing surfaces, and the equipment are closely related to the type of the injury (Beynnon, et al., 2005).

MECHANISM AND TYPES OF INJURY

Most ankle injuries are low-energy, rotational injuries occurring mainly in sport activities or by falls. Low force injuries (<20 mph) usually involve only soft tissue elements, whereas high velocity injuries (>20 mph) tend to cause fractures. Injury to the lateral side is far more common than injury to the medial ankle (Michelson, 1995). Injury during dorsiflexion is more likely to be bony, whereas injury during plantar flexion is more likely to be ligamentous. When the ankle is plantar flexed, it is less stable, and injuries tend to involve the lateral ankle (Birrer, et al., 1999).

The vast majority consists of injury to the lateral structures of the ankle. Typically, this involves injury to either or both the anterior talofibular ligament (ATFL) and/or the calcaneofibular ligament (CFL). The ATFL, which is the weaker of the two ligaments, functions mainly to restrict internal rotation of the talus underneath the bony mortise of the ankle while the CFL primarily resists adduction. Given the fact that in most lateral ligament injuries the mechanism of injury is inversion, plantar flexion, or internal rotation the ATFL is most frequently torn. The ATFL is injured in 85% of cases. In 20%, both the ATFL and the CFL are involved (Anderson, 1996; Marder, 1995).

Medial ankle sprains involve injury to the deltoid ligament alone and are as an isolated injury unusual. Typically, medial sprains and tears occur in combination with an injury to the lateral ligamentous or osseous structures.

High ankle sprains occur as a result of an external rotational injury. They can present in isolation but they mostly exist in the setting of medial and lateral sprain or bony injury. The term high ankle sprain refers to a sprain of the complex of ligaments responsible for stability at the inferior tibiofibular joint, the syndesmosis. High ankle sprains encompass the wide spectrum of injury from the minor sprain to the complete disruption of these structures, leading to diastasis.

The Lauge-Hansen classification attempted to associate specific fracture patterns with the mechanism of injury. According to this classification, most fractures are supination-eversion, supination-adduction, pronation-abduction, and pronation-eversion injuries. In this classification system, the term eversion is a misnomer; it more correctly should be external or lateral rotation. The first word in the designation refers to the foot's position at the time of injury; the second word refers to the direction of the deforming force.

The most common mechanism is supination-eversion (supination–external rotation). The identifying feature is a spiral oblique fracture of the distal fibula and a rupture of the deltoid ligament or fracture of the medial malleolus. The supination-adduction type of injury is characterized by a transverse fracture of the distal fibula and a relatively vertical fracture of the medial malleolus. The pronation-abduction mechanism produces a transverse fracture of the medial malleolus and a short oblique fracture of the fibula that appears relatively horizontal on the lateral radiograph. The pronation–eversion (pronation–external rotation) mechanism is characterized by a deltoid ligament tear or a fracture of the medial malleolus and a spiral oblique fracture of the fibula relatively high above the level of the ankle joint (Lieberman, 2009; S. Terry Canale, 2008).

CLINICAL EXAMINATION

Evaluation of ankle injuries begins with history, frequently the only method available to determine the mechanism of injury. The patient should be asked about the intensity of the force, field conditions, footwear, and disability immediately after the injury occurred. The report of a “crack” or “pop” at the time of injury may be described by the patient, but it does not reliably suggest a fracture. The exact mechanism of the injury, as described by the patient may indicate the type of ankle sprain or fracture. External rotation is a clue to a syndesmotic or high ankle sprain. Direct trauma or rotational injuries are more likely to cause fractures (Birrer, et al., 1999).

The examination of the ankle should be initiated with a thorough visual inspection noting abnormal swelling, redness, or deformities. Although a fracture is almost always associated with soft tissue swelling and ecchymosis, the degree of swelling is a poor indicator of injury severity (Birrer, et al., 1999). It continues with careful palpation of the ankle to determine the specific areas of point tenderness or extreme pain identify any abnormal bony prominences or incongruities, determine the extent of any swelling, and evaluation of the neurovascular status of the patient.

Inability to bear weight or walk may indicate fracture and is usually an indication for x-ray. Ability to walk does not exclude severe ligament injury or malleolar fracture.

There are several tests to evaluate the stability of the ankle joint, as the anterior-drawer test and the talar tilt test, but it is very difficult to gauge the severity of sprain accurately in the acute situation (Frey, Bell, Teresi, Kerr, & Feder, 1996), and so the degree of severity is usually assessed based on the ability to weight bear and the extent of the pain, swelling and bruising (Cooke, et al., 2009).

The squeeze test is performed to rule out disruption of the tibiofibular syndesmosis. The squeeze test is performed by squeezing the leg, approximating the tibia and fibula, at or slightly above the level of the belly of the gastrocnemius. An indication of syndesmotic disruption is pain at the distal tibiofibular articulation when the squeeze test is performed (Hopkinson et al, 1990).

If a fracture is ruled out, delayed physical examination for ankle sprains, four to five days after injury has determined to be the most reliable diagnostic strategy with a sensitivity of 96% and a specificity of 84%. The interobserver variation of this strategy has proved to be good, while it also proved to be cost effective (van Dijk, Lim, Bossuyt, & Marti, 1996; van Dijk, Mol, Lim, Marti, & Bossuyt, 1996).

IMAGING

After an acute ankle trauma it is important to rule out a fracture. X-ray including A-P, and lateral views should be performed in situations where acute bony tenderness is present on the malleoli or the medial or lateral dome of the talus. X rays of the ankle joint must include the base of the 5th metatarsal to exclude associated fracture.

At present, radiographs are ordered routinely in almost every patient with ankle trauma, although clinical significant fractures account for only 15% of the injuries (Stiell et al., 1994). The main reasons are mostly patient expectations and secondarily the doctor's fear of overlooking a fracture. This defensive approach may lead to unnecessary radiographical examinations, resulting in increased radiation exposure and health care expenditure, as well as longer waiting times in the emergency department (Bairstow, Persaud, Mendelson, & Nguyen, 2010; Perry & Stiell, 2006). Ankle films account for about 2% of all radiographic examinations and about 10% of emergency radiographs (Birrer, et al., 1999). An estimated

$500 million is spent annually in Canada and the United States on ankle radiographs alone (Stiell, 1996).

In order to reduce the need for radiography in patients with acute ankle trauma prediction rules have been developed. These rules have a purpose to reduce the amount of radiographs without the risk of missing clinical significant fractures. Clinical significant fractures are fractures that need treatment either surgical or conservative. The Ottawa Ankle Rules (OAR) (Figure 3) were developed in Canada and state that ankle radiographs are needed only if there is pain on palpation on the posterior edge of either malleolus or inability to walk four steps (I. G. Stiell et al., 1993; I. G. Stiell et al., 1992).

TREATMENT

When a diagnosis has been made and fracture is ruled out it is generally agreed, that non-operative treatment with early functional rehabilitation is the treatment of choice (Kannus & Renstrom, 1991).

Introduction of early range of motion, physical therapy modalities, appropriate splinting, and bracing, as opposed to casting, allows for the earlier restoration of function and avoidance of complications (Kannus & Renstrom, 1991; Kerkhoffs et al., 2002; Ogilvie-Harris & Gilbart, 1995; Pijnenburg, Van Dijk, Bossuyt, & Marti, 2000). Crutches are used if necessary. The bandage is worn for 1–3 weeks, depending on the symptoms. The static accumulation of hematoma, fluid extravasation, and resultant articular and tendinous adhesions is far less with treatment that promotes earlier rehabilitation. This type of treatment also helps to prevent arthrofibrosis and regional pain syndromes.

Severe ligament injury with clearly observed instability can be treated operatively by suturing the ligament and capsule if the patient is young (under 30–40 years old) and exercises actively (Kerkhoffs, Handoll, de Bie, Rowe, & Struijs, 2007). An actively exercising person can also be given an elastic bandage, and the corrective operation can be performed later if necessary. The tendency is to operate less frequently in the early stages because conservative treatment usually gives a good result (Ogilvie-Harris & Gilbart, 1995; Pijnenburg, et al., 2000).

The goal of treatment of ankle fractures is to restore the anatomic congruity of the ankle joint, promote pain free restoration of range of motion, and to restore and maintain fibular length. Stable fractures (lateral malleolar fractures with stable mortise and no medial swelling or tenderness) can be treated with Cam walkers or short-leg walking casts. Unstable fractures (lateral malleolar fractures with either mortise widening or medial swelling or tenderness) are treated with plating of the fibula (for spiral or oblique fractures) and two screws (for most medial malleolar fractures). Posterior malleolus fractures should be fixed if the fragments comprise >25% of the plateau joint surface, or if there is displacement after reduction (Michelson, 2003).

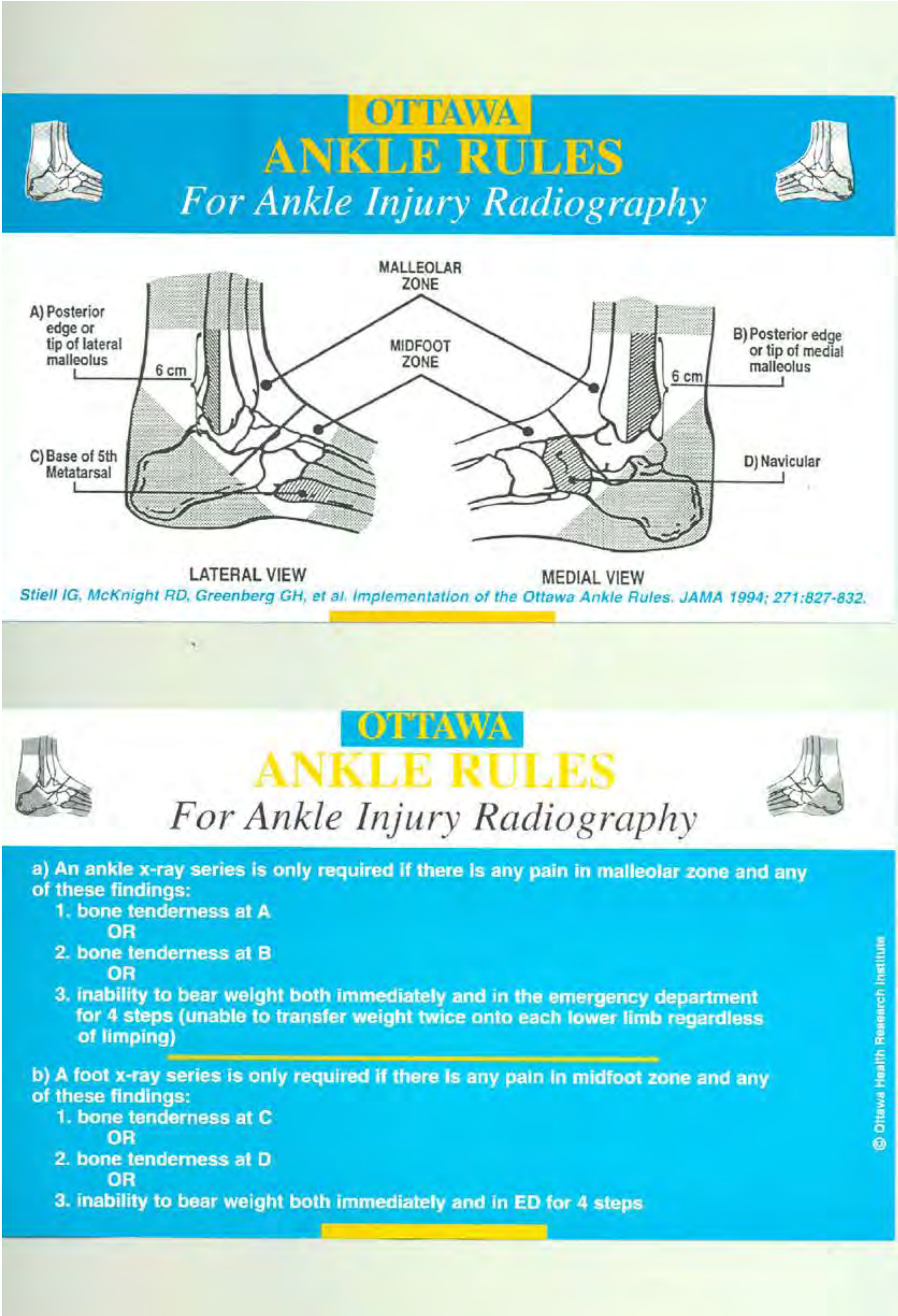


Figure 3 Ottawa Ankle Rules (OAR)

LITERATURE REVIEW

The Ottawa ankle rules are decision rules that help to determine which patients with ankle injuries should undergo radiography. The OAR were derived (N = 750) (I. G. Stiell, et al., 1992), refined, and prospectively validated (N = 1,485) (I. G. Stiell, et al., 1993) before two implementation trials, local implementation trial (N = 2,342) (I. G. Stiell, et al., 1994) and multicenter implementation trial (N = 12,777) (I. Stiell et al., 1995).

It was shown that the OAR has high sensitivity (almost 100%) in detecting fractures with a reduction in radiographies of approximately 40%. The same systematic review assessing the diagnostic value of the OAR revealed substantial heterogeneity of specificity ranging from 22,3 to 46,1 % (Bachmann, Kolb, Koller, Steurer, & ter Riet, 2003)

Unfortunately the Ottawa rules have proved unsuccessful in some populations (Chandra & Schafmayer, 2001)(Cameron & Naylor, 1999; Kelly et al., 1994; Tay, Thoo, Sitoh, Seow, & Wong, 1999). A possible explanation for this problem might be more or less severe ankle injury in different populations because of various thresholds for seeking medical assistance (Glas et al., 2002).

The OAR was validated in Greek athletes presented to the emergency departments of a district general hospital and a sports injury clinic by Papacostas et al in 2001. The sensitivity of the protocol was 100%. Specificity was estimated to be 0.3 for ankle fractures and 0.4 for midfoot fractures and a possible reduction of up to 28.7% was found in the need for radiography (Papacostas, Malliaropoulos, Papadopoulos, & Liouliakis, 2001).

Studies have suggested that poor knowledge of the Ottawa Ankle Rules (OAR) limits its clinical impact (Gravel, Roy, & Carriere, 2010).

Brehaut et al. reported a survey performed among Canadian emergency physicians to evaluate barriers to the implementation of clinical decision rules. While 99.2% of the respondents reported to be familiar with the OAR, only 30.9% were able to correctly remember all its components. Errors in remembering rule components were more common among part-time (beta = 0.18, p = .009) and older (beta = 0.18, p = 0.04) physicians, and those who do not apply the rule consistently (beta = 0.14, p = 0.04). Most physicians (89.6%) reported using the OAR always or most of the time in appropriate circumstances, while only 42.2% reported basing their decisions to order radiography primarily on the rule. Physicians reported considering non-rule factors that are not related to the presence of a fracture (e.g., swelling: 54%), and actors that add no more predictive value over and above the rule (e.g., age .55 years: 5.2%) (Brehaut, Stiell, Visentin, & Graham, 2005).

The reason for disagreement between clinical studies and real-life situations may be related to the fact that physicians do not adequately remember the OAR (Gravel, Roy, & Carriere, 2010) or because ordering unnecessary radiographs had no negative consequences (Bessen, Clark, Shakib, & Hughes, 2009) or even because physicians are hesitant to rely on the results of their physical examination (Can et al., 2008).

Gracham et al. evaluated the international diffusion of the Ottawa Ankle Rules and determined emergency physicians' attitudes toward clinical decision rules (Table 1). The results indicated that a majority of Canadian (89%) and U.K. (73%) EPs use the rules. However, less than one third of Spanish, French, and U.S. physicians reported frequent use of the rules (Graham et al., 2001).

Table 1 Awareness and use of Ottawa ankle rules (Graham, et al., 2001)

	Ottawa Ankle Rules*				
Variable	**Canada (n=375) (95% CI)**	**USA (n=227) (95% CI)**	**UK (n=295) (95% CI)**	**France (n=535) (95% CI)**	**Spain (n=270) (95% CI)**
Aware of rule†	373 99% (99–100)	217 96% (93–98)	268 91% (88–94)	371 69% (66–74)	56 21% (16–26)
Use of rule by those aware of it‡					
Always	34% (26–39)	2% (0–4)	20% (15–25)	8% (5–11)	4% (0–8)
Most of the time	55% (50–60)	30% (24–37)	61% (55–67)	36% (31–41)	38% (24–51)
Sometimes	9% (6–12)	46% (39–53)	13% (9–17)	34% (29–39)	41% (28–54)
Never	1% (0–2)	21% (16–27)	6% (3–9)	22% (18–26)	18% (8–28)
Use of rule by all respondents§					
Always/Most of the time	89% (86–92)	31% (25–37)	73% (68–78)	31% (27–35)	9% (6–12)

*Sixty-seven respondents elected not to answer this question.
† χ^2=653.5, P=.000
‡ χ^2=352.5, P=.000
§ χ^2=585.9, P=.000

In 1998 Leddy et al. presented a modification of the OAR to increase specificity for identifying malleolar fractures. The "Buffalo modification" (Figure 4) improved specificity for malleolar fractures (59% versus 42%) without sacrificing sensitivity and could significantly reduce the need for radiography (54%) (Leddy, Smolinski, Lawrence, Snyder, & Priore, 1998). Unfortunately the specificity of the Buffalo malleolar rule in the implementation study was not a significant improvement over the OAR malleolar rule (Leddy, Kesari, & Smolinski, 2002), so the rule cannot be widely accepted.

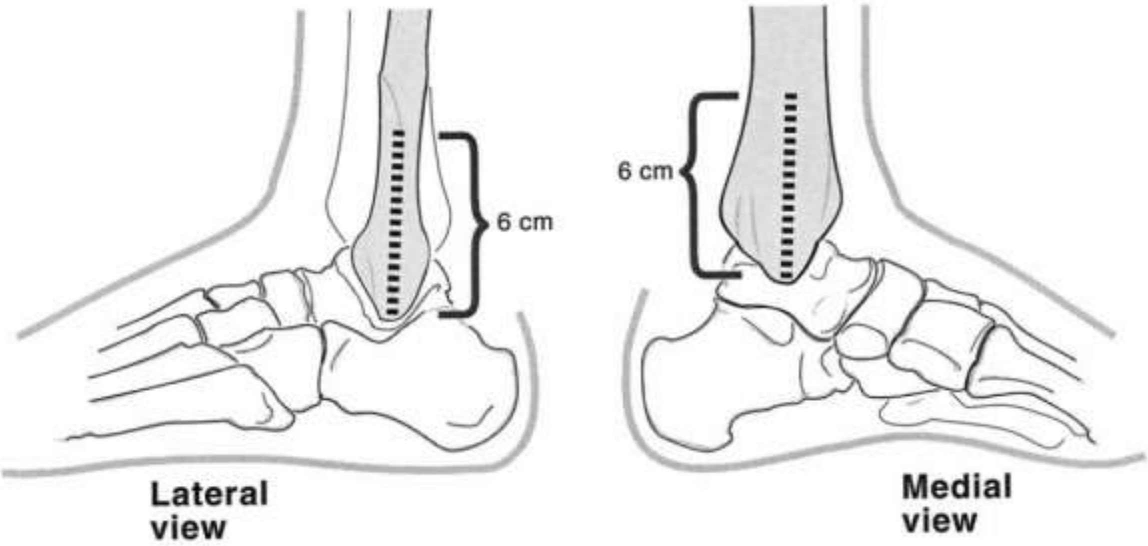


Figure 4 The Buffalo modification for malleolar tenderness moves the area of palpation to over the crests or midportions of the malleoli, away from the ligamentous attachments. The remainders of the OAR are otherwise the same (Leddy, et al., 1998).

A more complicated to use decision rule "the Leiden ankle rule" was developed at the university hospital of the city of Leiden in Netherlands in 1991. It consists of 7 rows of which each row consists of one or more variables. If per row at least one variable is positive, the stated score (weighted score) is given to that row, except for the last row, which depends on the age of the patient. If two variables are positive, the score is not doubled. For example, if both deformity and crepitation are positive, the score for that row is 5. The final score is the sum of the row scores (Table 2). The developers of the rule reported a sensitivity of 100% in detecting clinically significant fractures at this cutoff level (Glas, et al., 2002).

In a perspective study comparative study performed in Amsterdam, sensitivity was 89% for the Ottawa ankle rules and only 80% for the Leiden ankle rule, while specificity was 26%, 59% respectively(Glas, et al., 2002). The Leiden ankle rule missed to diagnose 5 clinical significant fractures, in the same study, so it cannot be used to detect ankle fractures.

Table 2 Leiden Ankle Rule

Clinical feature	Score*
Deformity, instability, crepitation	5
Inability to bear weight	3
Pulseless or weakened posterior tibial artery	2
Pain on palpation of malleoli or fifth metatarsal	2
Swelling of the malleoli or fifth metatarsal	2
Swelling or pain of the Achilles tendon	1
Age divided by 10	Variable

*If the sum of the individual scores exceeds 7, radiography is recommended.

Soft tissue injuries commonly elicit the physiological inflammatory response of redness, swelling, heat, and pain, and the acute ankle sprain injury is no exception (Nilsson & Haugen, 1981; Rourke, 1994). Measurable swelling was found to be a constant feature of ankle fractures (Montague & McQuillan, 1985). Based on this constant finding West proposed a ratio comparing the swelling, expressed as the bimalleolar diameter of the patient's injured ankle to that of the uninjured ankle. He stated that all the fractured ankles had a bimalleolar ratio above 1.065 (West, 1989). Stiell et al. found, however, that swelling was also influenced by time from injury and had less interobserver agreement than bone tenderness. Therefore, they believed that OAR would be more reliable without the inclusion of swelling (Stiell et al., 1992).

After an ankle injury it is important to determine the exact location of tenderness to establish ligamentous or osseous correlation. Shortly after injury, swelling is limited to the lateral ankle. Subsequently, the swelling is diffuse (Safran, Benedetti, Bartolozzi, &

Mandelbaum, 1999) making methods that measure the malleoli diameter or ankle circumference inadequate for accessing the volume of ankle edema.

The figure-of-eight method was demonstrated to be a reliable and valid indirect method of measuring ankle edema in individuals with edema secondary to sprains or other lower-extremity musculoskeletal disorders (Mawdsley, Hoy, & Erwin, 2000; Petersen et al., 1999; Rohner-Spengler, Mannion, & Babst, 2007). The figure-of-eight method (Figure 5) uses eight landmarks on the ankle and foot to measure ankle circumference in centimeters: (1) midway between the tibialis anterior tendon and the lateral malleolus, (2) distal to the tuberosity of the navicular, (3) proximal to the base of the 5th metatarsal, (4) tibialis anterior tendon, (5) distal to the distal tip of the medial malleolus, (6) Achilles tendon, (7) distal to the distal tip of the lateral malleolus, and (8) back to origin (Esterson, 1979). The figure-of-eight technique shows very high agreement with water volumetry (Friends, Augustine, & Danoff, 2008) and is an easy to easy, not time and money consuming method (Brodovicz et al., 2009; Petersen, et al., 1999) that can be easily accepted for evaluation of ankle injuries from emergency physicians'.

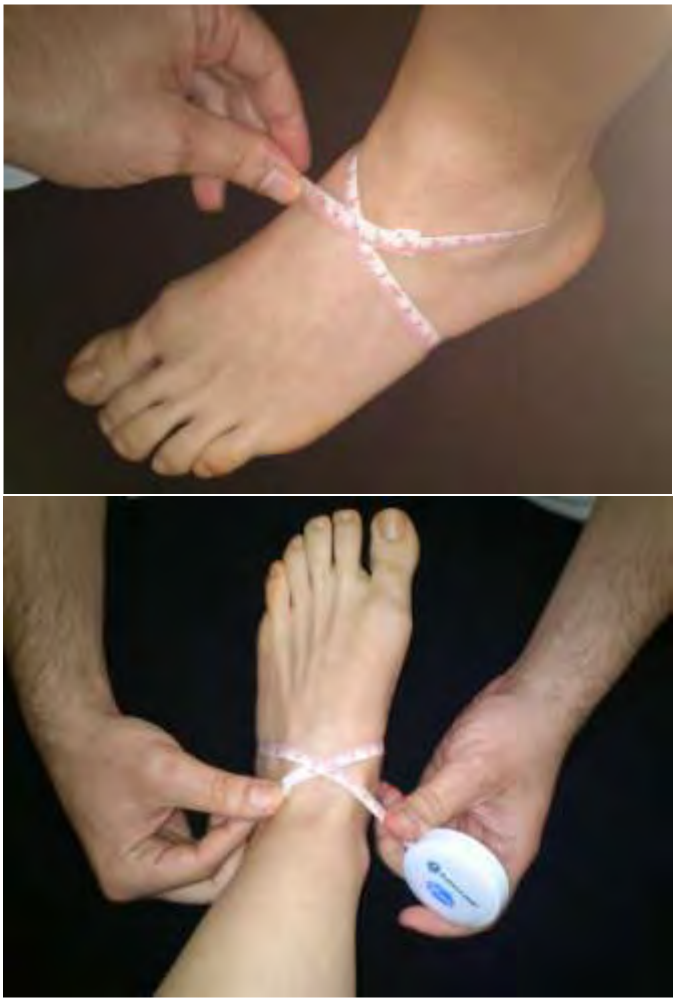


Figure 5 Figure of eight

The figure-of-eight method for measuring ankle swelling does not correlate with functional level (Pugia et al., 2001). A single measurement of the affected ankle cannot predict the type of the injury but the difference between the injured and the uninjured ankle may help to increase the diagnostic accuracy and specificity of the Ottawa ankle rules.

MATERIALS AND METHODS

In order to evaluate the OAR in the Greek population a study was performed to evaluate the accuracy in an average Greek hospital. A quantative method of measuring ankle edema was also used in order to investigate the possibility to increase the accuracy of the OAR.

This is a prospective study performed at a medium-sized hospital in Thessaloniki, Greece. Consecutive patients presenting to the emergency department with acute ankle injury between January and February 2012 were eligible. Acute ankle injury was defined as any case of painful ankle resulting from trauma. The ankle was defined as the malleolar area and the midfoot area, both of which are commonly involved in twisting injuries.

The patients were examined by resident orthopaedic surgeons. The examiners had to fulfill a predetermined form which contained a set of patients' characteristics and contextual information, such as age, gender, height, weight, injury mechanism and the time passed between the injury and examination. They also recorded the result of each item of the OAR separately along with the results of figure of eight measurement for both the ankles.

All examiners received a presentation about the use and interpretation of the rule and the figure of eight method of edema measurement and received a printed card with the descriptions. We also placed posters with a description of the OAR in the emergency department as suggested by the developers (Stiell et al., 1993; Stiell, et al., 1992)

All patients underwent a series of ankle x-rays (anteroposterior and lateral) and a series of mid-foot x-rays (anterioposterior and oblique) after the initial assessment. All radiographs were independently interpreted by a radiologist and an orthopaedic surgeon, who were both blinded to the information on the data form. Theirs interpretation was regarded as the reference against which we assessed the accuracy of the OAR and edema measurement.

A clinically significant fracture was any avulsed fracture fragment greater than 3 mm on the radiograph. If the avulsed fracture fragment was smaller than 3 mm, the radiograph was interpreted as a clinically insignificant fracture and was regarded as no fracture in data analysis.

Patients were excluded if they were under 18 years of age, if they were pregnant, if the ankle injury had occurred more than 5 days previously, if they were unreliable due to severely altered mental health, luck of cooperation or drug use.

Of the 123 patients presented with an ankle injury (9,7% of the patients presented for orthopaedic examination), 119 patients both met recruitment criteria and provided data for this study.

No changes in clinical management were made as a result of this study, so approval was not obligatory from the hospital's ethics committee, nor were the patients asked to provide informed consent.

OTTAWA ANKLE RULE

Όνομα:			
Ημερομηνία:			
Ηλικία:			Βάρος:
			Ύψος:
Φύλο:	Άνδρας	Γυναίκα	

Χρόνος από το ατύχημα (σε ώρες):

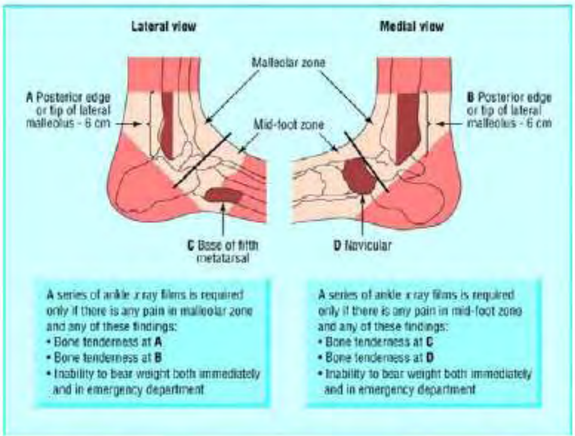
Μηχανισμός τραυματισμού:	Πτώση	Τροχαίο ατύχημα	Αθλητική κάκωση	Άλλο

ΠΟΔΟΚΝΗΜΙΚΗ

			OAR
Ευαισθησία στα σφυρά	ΝΑΙ	ΟΧΙ	
Μπορεί να φορτίσει το σκέλος και να κάνει 4 βήματα	ΝΑΙ	ΟΧΙ	

ΜΕΣΟ ΠΟΔΙ

			OAR
Ευαισθησία στο σκαφοειδές ή στο 5° μετατάρσιο	ΝΑΙ	ΟΧΙ	
Μπορεί να φορτίσει το σκέλος και να κάνει 4 βήματα	ΝΑΙ	ΟΧΙ	



- Ως ευαισθησία στα σφυρά ορίζεται η ευαισθησία στα τελευταία 6 εκατοστά (οπίσθιο χείλος) ή στην κορυφή της κνήμης ή της περόνης
- Η ικανότητα να φορτίσει το σκέλος και να κάνει 4 βήματα αναφέρεται είτε στον τόπο του ατυχήματος, είτε στο ΤΕΠ

ΚΑΤΑΓΜΑ	ΝΑΙ	ΟΧΙ

- Ως κάταγμα ορίζεται η ύπαρξη αποσπασμένου οστικού τεμαχίου >3mm

<u>Υγιές</u> <u>Πάσχων</u>

Figure of eight

Figure 6 Ankle injury record form

STATISTICAL ANALYSIS

We calculated the diagnostic capability of the two rules (OAR and edema ankle measurement) in terms of sensitivity, specificity, and the potential reduction of radiographies needed. Receiver operating characteristics (ROC) curves were created and the area under the curve (AUC) was calculated for the 2 decision rules in order to evaluate the discriminating performance of each rule. To draw the ROC curve for the OAR we combined foot and ankle criteria (inability to bear weight for 4 steps, bone tenderness at the malleoli and bone tenderness at the base of the 5th metatarsal or at the navicular) and created thresholds from 0 items positive through 3 items positive. To compare whether differences between the AUC of the ROC curves were statistically significant the method of Hanley and McNeil was used (Hanley & McNeil, 1983). The McNemar test for paired samples was used to compare the percentage of patients for whom radiography was recommended according to the prediction rules.

All the quantitative variables were checked for the regularity of their distribution according to the criterion of Kolmogorov-Smirnov. Where normal distribution did not exist non parametric methods of presentation of variables and analysis were used. Analyses were performed with the IBM SPSS Statistics Version 20.

RESULTS

During the study 1268 patients were referred to the orthopaedic emergency department of our hospital out of which 123 with an acute ankle trauma. 4 of these patients met the exclusion criteria or refused to participate and had to be excluded from the study. The mean age of the 119 patients included in the study was 38,46 and the mean body mass index (BMI) was 26,11 (Table 3). 57 of the patients were males (47,9%) and 62 were females. Almost half of the patients (47,6%) did not train at all and only 30,5% claimed that they exercise systematically (2-3 times per week).

Table 3 Patients' characteristics

Patients' characteristics	Mean	SD	Minimum	Maximum
Age	38,46	16,630	18	78
BMI	26,1108	4,65164	18,42	37,74

The mechanism of the injury was mostly a simple fall. Almost one fourth of the injuries happened during sport activities (Table 4).

Table 4 Mechanism of injury

	Frequency	Percent
Simple fall	75	63,0
Traffic accident	9	7,6
Sports	29	24,4
Other causes – undefined	6	5,0

In total 34 clinical significant fractures were observed on the radiographs, 16 in males (47,1%) and 18 in females (52,9%). Patients who sustained a fracture were older than patients without a fracture and that difference was statistically significant (U=964.000, p=0.005, two-tailed).

Table 5 Correlations for fracture

		FRACTURE				
		Yes		No		
		N	%	N	%	p
SEX	Males	16	47,1%	41	48,2%	0,908
	Females	18	52,9%	44	51,8%	

	FRACTURE					
	Yes		No			
	Median	IQR	Median	IQR	Asymp. Sig. (2-tailed)	Mann-Whitney U
AGE	46,0	29,0	30,0	22,0	0,005	964,000
WEIGHT	75,5	25,0	75,0	21,0	0,578	1350,500
BMI	26,0	6,7	24,9	6,8	0,642	1366,000

Note: IQR = interquartile range

The time between the injury and the evaluation at the emergency department did not play any important role in edema formation. On the contrary there is important difference between those who are able to make four steps and those not, in correlation with the time passed between injury and examination (Table 6).

There was positive correlation between edema formation and age (rho=0.242, p=0.008). There was not any correlation between edema formation and BMI or sex (Table 7).

Table 6 Correlations with time from injury

	TIME FROM INJURY UNTILL EXAMINATION

		Median	IQR	Asymp. Sig. (2-tailed)	Mann-Whitney U
EDEMA >1cm	Positive	6,5	22,0	0,821	1721,500
	Negative	10,0	15,5		
TENDERNESS AT THE MALLEOLI	Yes	7,5	18,0	0,495	1589,000
	No	9,0	16,0		
ABILITY TO BEAR WEIGHT FOR 4 STEPS	Yes	12,0	20,0	0,001[a]	1018,500
	No	3,0	12,5		

			EDEMA
Spearman's rho	TIME FROM INJURY UNTILL EXAMINATION	Correlation Coefficient	0,057
		Sig. (2-tailed)	0,535
		N	119

Note: IQR = interquartile range
[a] There is a statistically significant difference for those who are able to make four steps and those not in correlation with time from injury (U=1018.500, p=0.001, two-tailed).

Table 7 Correlations of edema

			EDEMA		
			Median	ICQ	p
SEX		Males	1,5	1,5	0,100
		Females	1,0	1,5	
		Age	Weight	Height	BMI
EDEMA	Spearman's rho	0,242	0,072	0,146	0,013
	P	0,008	0,438	0,113	0,886
	N	119	119	119	119

Note: IQR = interquartile range

The Ottawa Ankle Rules identified 32 of the 34 clinical significant fractures (sensitivity 94,12% and specificity 37,65%) (Table 8). The ankle edema measurement identified all 34 fractures (sensitivity 100% and specificity 74,12%) (Table 9).

Table 8 Criterion values and coordinates of the ROC curve for OAR

Criterion	Sensitivity	95% CI	Specificity	95% CI
>=0	100,00	89,7 - 100,0	0,00	0,0 - 4,2
>0	94,12	80,3 - 99,3	37,65	27,4 - 48,8
>1	58,82	40,7 - 75,4	75,29	64,7 - 84,0

>2	5,88	0,7 - 19,7	97,65	91,8 - 99,7
>3	0,00	0,0 - 10,3	100,00	95,8 - 100,0

Table 9 Criterion values and coordinates of the ROC curve for ankle edema

Criterion	Sensitivity	95% CI	Specificity	95% CI
>=0	100,00	89,7 - 100,0	0,00	0,0 - 4,2
>0	100,00	89,7 - 100,0	27,06	18,0 - 37,8
>0,5	100,00	89,7 - 100,0	44,71	33,9 - 55,9
>1 *	100,00	89,7 - 100,0	74,12	63,5 - 83,0
>1,5	76,47	58,8 - 89,3	78,82	68,6 - 86,9
>2	50,00	32,4 - 67,6	92,94	85,3 - 97,4
>2,5	47,06	29,8 - 64,9	94,12	86,8 - 98,1
>3	23,53	10,7 - 41,2	97,65	91,8 - 99,7
>4	14,71	5,0 - 31,1	100,00	95,8 - 100,0
>4,5	11,76	3,3 - 27,5	100,00	95,8 - 100,0
>5	2,94	0,07 - 15,3	100,00	95,8 - 100,0
>6	0,00	0,0 - 10,3	100,00	95,8 - 100,0

* Criterion corresponding with highest Youden index

The OAR recommended radiography in 71,4% of the cases when the ankle edema measurement recommended radiography in only 47,1%. The corresponding potential savings in radiographs were 28,6% for the Ottawa rules and 52,9% for the ankle edema measurement (Table 10).

Table 10 Crosstab of edema and OAR

	OAR		
Edema >1cm	Positive	Negative	
Positive	47	9	56 (47,1%)
Negative	38	25	63 (52,9%)
	85 (71,4%)	34 (28,6%)	119

The McNemar test showed a significant difference between the two sets of decision rules in terms of the percentage of cases in which radiography was recommended (p<0.001) (Table 11).

Table 11 McNemar test for edema and OAR

Chi-square	16,6809
Significance	P < 0,0001

The ROC curves are shown in figure 7. The area under these curves expresses the performance of each diagnostic tool in distinguishing patients with a fracture from those without a fracture for all possible cutoff values. The AUC for the Ottawa ankle rules (0,726) was significantly lower than the AUC for the ankle edema measurement (0,895; p=0,0017) (Table 12).

Table 12 Diagnostic performance indicators for the decision rules

	Sensitivity (and 95% CI)	Specificity (and 95% CI)	AUC (and 95% CI)
Ottawa Ankle Rules	94,12% (80,3 - 99,3%)	37,65% (27,4 - 48,8%)	0,726 (0,637 - 0,804)
Ankle edema measurement	100% (89,7 – 100%)	74,12% (63,5 - 83,0%)	0,895[a] (0,825 - 0,943)

Note: CI = confidence interval, AUC = area under the curve of the ROC
[a]The AUC for the ankle edema measurement was significantly different from the AUC of the Ottawa ankle rules (Hanley and McNeil test; p=0.0017)

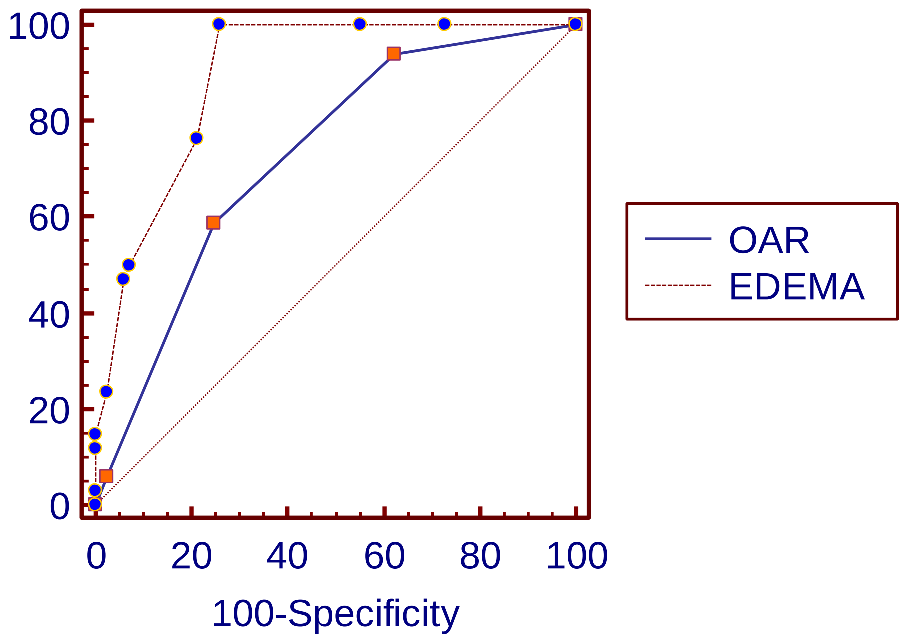


Figure 7 Receiver operating characteristic curves for OAR and Ankle Edema

DISCUSSION

Until now many decisions to perform investigations are based on personal experience and not evidence-based medicine. In the present socio economical status doctors have to deal with rising pressure to provide proper health care with less cost. Clinical decision rules (CDRs) are tools that help clinicians make diagnostic and therapeutic decisions at the bedside. By standardizing the collection and interpretation of clinical data, CDRs attempt to reduce uncertainty in medical decision-making (Stiell & Bennett, 2007). It is important to ensure that the sensitivity and specificity of the rule are accurate and that there are few missed diagnoses.

Since the early 1980s, several studies have been conducted to establish predictive rules for the use of radiography in ankle injuries. The better established and validated protocol seemed to be the OAR. Our study proved that the OAR can be used in the Greek population.

We found 94,12% sensitivity, and 37,65% specificity, with a possible reduction of 28,57% in use of radiographs. Our results are similar to those found in literature (Beynnon, et al., 2002).

In the Greek national health system every patient with a musculoskeletal injury is examined and assessed by either orthopaedic residents or consultants so there are no discrepancies observed in other studies which arise mainly because of differences in level of clinical training and experience. Greek patients use to demand an x-ray examination, believing that an x-ray is the only way to rule out a fracture. They are also reluctant to be examined and to provide the proper information. Doctor's fear of a bad professional reputation or litigation by missing a fracture leads him to overestimate patients' complaints and therefore maximizes sensitivity while on the same time minimizes specificity. Soft-tissue tenderness and swelling make bone tenderness difficult to assess. It also appears plausible that the subtlety of palpation technique might impact on the false-positive rates, that is, the percentages of patients who apparently indicated pain or inability to walk four steps, but had no fracture (Can, et al., 2008). We think that the main disadvantage of the OAR is that is influenced by subjective factors.

The OAR is calibrated towards high sensitivity at optimal specificity. High sensitivity minimizes false negative results. On the other hand specificity correlates with the usefulness of the rule in helping avoid unnecessary x-rays and associated costs. Edema measurement with the figure of eight method as a standalone method can more accurately predict an ankle fracture (sensitivity 100%, specificity 74,12%, accuracy 81,51%). The possible reduction in the number of radiographs taken is extremely high (52,94%) and the possible cost reduction remarkable. The main advantage is that it is an objective method which relays in an easy to use, not time or money consuming measurement. We believe that the method fulfill both the physicians' (comfort and compliance with use of the rule) and patients' (satisfaction with care) perspectives, in order to be widely accepted.

No clinical decision rule can be considered valid until it has been prospectively assessed because many guidelines do not perform as well when tested on a new group of patients. Developing and testing a CDR involves three stages: creating or deriving the rule (derivation study); prospective assessment of the rule's accuracy, reliability, and potential impact (validation study); and assessment of the rule's impact on patient care (implementation study) (Stiell & Bennett, 2007). The new rule must be further assessed to prove its relative advantages before the implementation as a method to rule out possible ankle fractures without the use of radiography.

It is obvious that in times of increased legal pressure and the growing obligation to document and prove clinical findings for social and health insurance purposes it is likely that the performance of the decision rules measured in a study can not be reached in clinical practice. In our study as in almost every other earlier validation study all patients underwent radiography irrespective of the decision rule result. So the capacity of the rule to reduce the number of unnecessary x-rays remains somewhat theoretical.

CONCLUSIONS

Emergency physicians around the world should adopt the use of clinical decision rules for ankle injuries. With relatively simple implementation strategies, care can be standardized and costs reduced while providing excellent clinical care. Implementation of decision rules that are cost effective without compromising the acute or chronic medical situation of a patient are of great acceptance. The edema measurement rule for ankle injuries seems to be an accurate, objective, cost effective alternative to rule out ankle fractures.

SUGGESTIONS FOR FURTHER WORK

Developing and testing a CDR involves three stages: creating or deriving the rule (derivation study); prospective assessment of the rule's accuracy, reliability, and potential impact (validation study); and assessment of the rule's impact on patient care (implementation study) (Stiell & Bennett, 2007).

This study was only the derivation study of edema measurement rule. The new rule must be prospectively validated on a new set of patients in order to prove it's potentials in predicting ankle fractures. Implementation studies of the rule in other hospitals or even other health systems will provide evidence of the rule's true effect in ankle fracture recognition and patient care improvement.

REFERENCES

Anandacoomarasamy, A., & Barnsley, L. (2005). Long term outcomes of inversion ankle injuries. *British journal of sports medicine*, *39*(3), e14; discussion e14.

Anderson, S. J. (1996). Evaluation and treatment of ankle sprains. [Review]. *Comprehensive therapy, 22*(1), 30-38.

Bachmann, L. M., Kolb, E., Koller, M. T., Steurer, J., & ter Riet, G. (2003). Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. [Meta-Analysis

Review]. *BMJ, 326*(7386), 417.

Bessen, T., Clark, R., Shakib, S., & Hughes, G. (2009). A multifaceted strategy for implementation of the Ottawa ankle rules in two emergency departments. [Multicenter Study

Research Support, Non-U.S. Gov't]. *BMJ, 339*, b3056.

Beynnon, B. D., Murphy, D. F., & Alosa, D. M. (2002). Predictive Factors for Lateral Ankle Sprains: A Literature Review. *Journal of athletic training, 37*(4), 376-380.

Beynnon, B. D., Vacek, P. M., Murphy, D., Alosa, D., & Paller, D. (2005). First-time inversion ankle ligament trauma: the effects of sex, level of competition, and sport on the incidence of injury. [Research Support, N.I.H., Extramural

Research Support, U.S. Gov't, P.H.S.]. *The American journal of sports medicine, 33*(10), 1485-1491.

Birrer, R. B., Fani-Salek, M. H., Totten, V. Y., Herman, L. M., & Politi, V. (1999). Managing ankle injuries in the emergency department. [Review]. *The Journal of emergency medicine, 17*(4), 651-660.

Brehaut, J. C., Stiell, I. G., Visentin, L., & Graham, I. D. (2005). Clinical decision rules "in the real world": how a widely disseminated rule is used in everyday practice. [Research Support, Non-U.S. Gov't]. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine, 12*(10), 948-956.

Brodovicz, K. G., McNaughton, K., Uemura, N., Meininger, G., Girman, C. J., & Yale, S. H. (2009). Reliability and feasibility of methods to quantitatively assess peripheral edema. [Research Support, Non-U.S. Gov't]. *Clinical medicine & research, 7*(1-2), 21-31.

Can, U., Ruckert, R., Held, U., Buchmann, P., Platz, A., & Bachmann, L. M. (2008). Safety and efficiency of the Ottawa Ankle Rule in a Swiss population with ankle sprains. *Swiss Med Wkly, 138*(19-20), 292-296.

Cass, J. R., & Morrey, B. F. (1984). Ankle instability: current concepts, diagnosis, and treatment. *Mayo Clinic proceedings. Mayo Clinic, 59*(3), 165-170.

Chandra, A., & Schafmayer, A. (2001). [Diagnostic value of a clinical test for exclusion of fractures after acute ankle sprains. A prospective study for evaluating the "Ottowa Ankle Rules" in Germany]. *Der Unfallchirurg, 104*(7), 617-621.

Cooke, M. W., Marsh, J. L., Clark, M., Nakash, R., Jarvis, R. M., Hutton, J. L., et al. (2009). Treatment of severe ankle sprain: a pragmatic randomised controlled trial comparing the clinical effectiveness and cost-effectiveness of three types of mechanical ankle support with tubular bandage. The CAST trial. [Comparative Study

Multicenter Study

Randomized Controlled Trial]. *Health technology assessment, 13*(13), iii, ix-x, 1-121.

Esterson, P. S. (1979). Measurement of ankle joint swelling using a figure of 8*. *The Journal of orthopaedic and sports physical therapy, 1*(1), 51-52.

Frey, C., Bell, J., Teresi, L., Kerr, R., & Feder, K. (1996). A comparison of MRI and clinical examination of acute lateral ankle sprains. [Comparative Study]. *Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society, 17*(9), 533-537.

Friends, J., Augustine, E., & Danoff, J. (2008). A comparison of different assessment techniques for measuring foot and ankle volume in healthy adults. [Comparative Study

Controlled Clinical Trial]. *Journal of the American Podiatric Medical Association, 98*(2), 85-94.

Garrick, J. G., & Requa, R. K. (1988). The epidemiology of foot and ankle injuries in sports. *Clinics in sports medicine, 7*(1), 29-36.

Gerber, J. P., Williams, G. N., Scoville, C. R., Arciero, R. A., & Taylor, D. C. (1998). Persistent disability associated with ankle sprains: a prospective examination of an athletic population. [Comparative Study]. *Foot & ankle international / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society, 19*(10), 653-660.

Glas, A. S., Pijnenburg, B. A., Lijmer, J. G., Bogaard, K., de, R. M., Keeman, J. N., et al. (2002). Comparison of diagnostic decision rules and structured data collection in assessment of acute ankle injury. [Comparative Study]. *CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne, 166*(6), 727-733.

Graham, I. D., Stiell, I. G., Laupacis, A., McAuley, L., Howell, M., Clancy, M., et al. (2001). Awareness and use of the Ottawa ankle and knee rules in 5 countries: can publication alone be enough to change practice? *Ann Emerg Med, 37*(3), 259-266.

Gravel, J., Roy, M., & Carriere, B. (2010). 44-55-66-PM, a mnemonic that improves retention of the Ottawa Ankle and Foot Rules: a randomized controlled trial. [Randomized Controlled Trial]. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine, 17*(8), 859-864.

Hanley, J. A., & McNeil, B. J. (1983). A method of comparing the areas under receiver operating characteristic curves derived from the same cases. [Research Support, Non-U.S. Gov't]. *Radiology, 148*(3), 839-843.

Jesse C. DeLee MD, D. D. J. M., Mark D. Miller. (2003). *DeLee and Drez's Orthopaedic Sports Medicine*: Elsevier Health Sciences.

Kannus, P., & Renstrom, P. (1991). Treatment for acute tears of the lateral ligaments of the ankle. Operation, cast, or early controlled mobilization. [Review]. *The Journal of bone and joint surgery. American volume, 73*(2), 305-312.

Kerkhoffs, G. M., Handoll, H. H., de Bie, R., Rowe, B. H., & Struijs, P. A. (2007). Surgical versus conservative treatment for acute injuries of the lateral ligament complex of the ankle in adults. [Meta-Analysis

Review]. *Cochrane database of systematic reviews*(2), CD000380.

Kerkhoffs, G. M., Struijs, P. A., Marti, R. K., Assendelft, W. J., Blankevoort, L., & van Dijk, C. N. (2002). Different functional treatment strategies for acute lateral ankle ligament injuries in adults. [Review]. *Cochrane database of systematic reviews*(3), CD002938.

Konradsen, L., Bech, L., Ehrenbjerg, M., & Nickelsen, T. (2002). Seven years follow-up after ankle inversion trauma. *Scandinavian journal of medicine & science in sports, 12*(3), 129-135.

Leddy, J. J., Kesari, A., & Smolinski, R. J. (2002). Implementation of the Ottawa ankle rule in a university sports medicine center. *Med Sci Sports Exerc, 34*(1), 57-62.

Leddy, J. J., Smolinski, R. J., Lawrence, J., Snyder, J. L., & Priore, R. L. (1998). Prospective evaluation of the Ottawa Ankle Rules in a university sports medicine center. With a modification to increase specificity for identifying malleolar fractures. *The American journal of sports medicine, 26*(2), 158-165.

Lieberman, J. R. (Ed.). (2009). *AAOS Comprehensive Orthopaedic Review*.

Marder, R. A. (1995). Current methods for the evaluation of ankle ligament injuries. [Review]. *Instructional course lectures, 44*, 349-357.

Mawdsley, R. H., Hoy, D. K., & Erwin, P. M. (2000). Criterion-related validity of the figure-of-eight method of measuring ankle edema. *The Journal of orthopaedic and sports physical therapy, 30*(3), 149-153.

Michelson, J. D. (1995). Fractures about the ankle. [Review]. *The Journal of bone and joint surgery. American volume, 77*(1), 142-152.

Michelson, J. D. (2003). Ankle fractures resulting from rotational injuries. [Review]. *The Journal of the American Academy of Orthopaedic Surgeons, 11*(6), 403-412.

Montague, A. P., & McQuillan, R. F. (1985). Clinical assessment of apparently sprained ankle and detection of fracture. *Injury, 16*(8), 545-546.

Nilsson, S., & Haugen, G. B. (1981). Volumetry in the evaluation of swelling in the ankle and foot. *Journal of the Oslo city hospitals, 31*(1), 11-15.

Ogilvie-Harris, D. J., & Gilbart, M. (1995). Treatment modalities for soft tissue injuries of the ankle: a critical review. [Meta-Analysis]. *Clinical journal of sport medicine : official journal of the Canadian Academy of Sport Medicine, 5*(3), 175-186.

Petersen, E. J., Irish, S. M., Lyons, C. L., Miklaski, S. F., Bryan, J. M., Henderson, N. E., et al. (1999). Reliability of water volumetry and the figure of eight method on subjects with ankle joint swelling. [Clinical Trial

Comparative Study

Randomized Controlled Trial]. *The Journal of orthopaedic and sports physical therapy, 29*(10), 609-615.

Pijnenburg, A. C., Van Dijk, C. N., Bossuyt, P. M., & Marti, R. K. (2000). Treatment of ruptures of the lateral ankle ligaments: a meta-analysis. [Meta-Analysis]. *The Journal of bone and joint surgery. American volume, 82*(6), 761-773.

Pugia, M. L., Middel, C. J., Seward, S. W., Pollock, J. L., Hall, R. C., Lowe, L., et al. (2001). Comparison of acute swelling and function in subjects with lateral ankle injury. [Comparative Study

Evaluation Studies]. *The Journal of orthopaedic and sports physical therapy, 31*(7), 384-388.

Rohner-Spengler, M., Mannion, A. F., & Babst, R. (2007). Reliability and minimal detectable change for the figure-of-eight-20 method of, measurement of ankle edema. *The Journal of orthopaedic and sports physical therapy, 37*(4), 199-205.

Rourke, K. (1994). The evaluation and treatment of acute ankle sprains. *Journal of emergency nursing: JEN : official publication of the Emergency Department Nurses Association, 20*(6), 528-535; quiz 536-529.

S. Terry Canale, J. H. B. (2008). *Campbell's operative orthopaedics, 11th ed*: MOSBY ELSEVIER.

Safran, M. R., Benedetti, R. S., Bartolozzi, A. R., 3rd, & Mandelbaum, B. R. (1999). Lateral ankle sprains: a comprehensive review: part 1: etiology, pathoanatomy, histopathogenesis, and diagnosis. [Review]. *Medicine and science in sports and exercise, 31*(7 Suppl), S429-437.

Stiell, I. G., & Bennett, C. (2007). Implementation of clinical decision rules in the emergency department. *Academic emergency medicine : official journal of the Society for Academic Emergency Medicine, 14*(11), 955-959.

Stiell, I. G., Greenberg, G. H., McKnight, R. D., Nair, R. C., McDowell, I., Reardon, M., et al. (1993). Decision rules for the use of radiography in acute ankle injuries. Refinement and prospective validation. [Research Support, Non-U.S. Gov't]. *JAMA : the journal of the American Medical Association, 269*(9), 1127-1132.

Stiell, I. G., Greenberg, G. H., McKnight, R. D., Nair, R. C., McDowell, I., & Worthington, J. R. (1992). A study to develop clinical decision rules for the use of radiography in acute ankle injuries. *Ann Emerg Med, 21*(4), 384-390.

Stiell, I. G., McKnight, R. D., Greenberg, G. H., McDowell, I., Nair, R. C., Wells, G. A., et al. (1994). Implementation of the Ottawa ankle rules. [Clinical Trial
Research Support, Non-U.S. Gov't]. *JAMA : the journal of the American Medical Association, 271*(11), 827-832.

West, A. (1989). Assessing the injured ankle without X-rays. *Br J Clin Pract, 43*(10), 360-362.

Yeung, M. S., Chan, K. M., So, C. H., & Yuan, W. Y. (1994). An epidemiological survey on ankle sprain. *British journal of sports medicine, 28*(2), 112-116.

APPENDICES

ΠΑΝΕΠΙΣΤΗΜΙΟ ΘΕΣΣΑΛΙΑΣ
ΤΜΗΜΑ ΕΠΙΣΤΗΜΗΣ ΦΥΣΙΚΗΣ ΑΓΩΓΗΣ ΚΑΙ ΑΘΛΗΤΙΣΜΟΥ

Εσωτερική Επιτροπή Δεοντολογίας

Τρίκαλα: 29/3/2012
Αριθμ. Πρωτ.: 528

Αίτηση Εξέτασης της πρότασης για διεξαγωγή Έρευνας με τίτλο:
"Η επίδραση της μέτρησης του οιδήματος της ποδοκνημικής στη βελτίωση της αξιοπιστίας του πρωτοκόλλου Otawa Ankle Rule"

Επιστημονικώς υπεύθυνος-η / επιβλέπων-ουσα: Γιάκας Ιωάννης
Ιδιότητα: Επίκουρος Καθηγητής
Ίδρυμα: Πανεπιστήμιο Θεσσαλίας
Τμήμα: Τμήμα Φυσικής Αγωγής και Αθλητισμού

Κύριος ερευνητής-τρια / φοιτητής-τρια: Σπανός Ιωάννης
Πρόγραμμα Σπουδών: ΠΜΣ «Άσκηση και Υγεία»
Ίδρυμα: Πανεπιστήμιο Θεσσαλίας
Τμήμα: Τμήμα Φυσικής Αγωγής και Αθλητισμού

Η προτεινόμενη έρευνα θα είναι:

Ερευνητικό πρόγραμμα ☐ Μεταπτυχιακή διατριβή X Διπλωματική εργασία ☐ Ανεξάρτητη έρευνα ☐

Τηλ. επικοινωνίας: 6977283470
Email επικοινωνίας: spanosyannis@yahoo.gr

Η Εσωτερική Επιτροπή Δεοντολογίας του Τ.Ε.Φ.Α.Α., Πανεπιστημίου Θεσσαλίας μετά την υπ. Αριθμ. 2-7/22-2-2012 συνεδρίαση της εγκρίνει τη διεξαγωγή της προτεινόμενης έρευνας.

Ο Πρόεδρος της
Εσωτερικής Επιτροπής
Δεοντολογίας – ΤΕΦΑΑ

Τσιόκανος Αθανάσιος
Αναπληρωτής Καθηγητής

Υπεύθυνη Δήλωση

Ο κάτωθι υπογεγραμμένος Σπανός Ιωάννης του Νικολάου με Α.Μ. 20/08, μεταπτυχιακός φοιτητής του Προγράμματος Μεταπτυχιακών Σπουδών «Άσκηση και Υγεία» του Τμήματος Επιστήμης Φυσικής Αγωγής και Αθλητισμού του Πανεπιστημίου Θεσσαλίας

δηλώνω υπεύθυνα ότι αποδέχομαι τους παρακάτω όρους που αφορούν

(α) στα πνευματικά δικαιώματα της Μεταπτυχιακής Διπλωματικής Εργασίας (ΜΔΕ) μου με τίτλο «Η ΕΠΙΔΡΑΣΗ ΤΗΣ ΜΕΤΡΗΣΗΣ ΤΟΥ ΟΙΔΗΜΑΤΟΣ ΤΗΣ ΠΟΔΟΚΝΗΜΙΚΗΣ ΣΤΗ ΒΕΛΤΙΩΣΗ ΤΗΣ ΑΞΙΟΠΙΣΤΙΑΣ ΤΟΥ ΠΡΩΤΟΚΟΛΛΟΥ OTTAWA ANKLE RULES»

(β) στη διαχείριση των ερευνητικών δεδομένων που θα συλλέξω στην πορεία εκπόνησής της:

1. Τα πνευματικά δικαιώματα του τόμου της μεταπτυχιακής διατριβής που θα προκύψει θα ανήκουν σε μένα. Θα ακολουθήσω τις οδηγίες συγγραφής, εκτύπωσης και κατάθεσης αντιτύπων της διατριβής στα ανάλογα αποθετήρια (σε έντυπη ή/και σε ηλεκτρονική μορφή).

2. Η διαχείριση των δεδομένων της διατριβής ανήκει από κοινού σε εμένα και στον επιβλέποντα καθηγητή.

3. Οποιαδήποτε επιστημονική δημοσίευση ή ανακοίνωση (αναρτημένη ή προφορική), ή αναφορά που προέρχεται από το υλικό/δεδομένα της εργασίας αυτής θα γίνεται με συγγραφείς εμένα τον ίδιο, τον κύριο επιβλέποντα ή και άλλους ερευνητές (όπως πχ μέλους –ών της τριμελούς συμβουλευτικής επιτροπής), ανάλογα με τη συμβολή τους στην έρευνα ή στη συγγραφή των ερευνητικών εργασιών.

4. Η σειρά των ονομάτων στις επιστημονικές δημοσιεύσεις ή επιστημονικές ανακοινώσεις θα αποφασίζεται από κοινού από εμένα και τον κύριο επιβλέποντα της εργασίας, πριν αρχίσει η εκπόνησή της. Η απόφαση αυτή θα πιστοποιηθεί εγγράφως μεταξύ εμού και του κ. επιβλέποντα.

Τέλος, δηλώνω ότι γνωρίζω τους κανόνες περί λογοκλοπής και πνευματικής ιδιοκτησίας και ότι θα τους τηρώ απαρέγκλιτα καθ' όλη τη διάρκεια της φοίτησης και κάλυψης των εκπαιδευτικών υποχρεώσεων που προκύπτουν από το ΠΜΣ/τμήμα, αλλά και των διαδικασιών δημοσίευσης που θα προκύψουν μετά την ολοκλήρωση των σπουδών μου.

23/10/2012

Ο δηλών

Ιωάννης Σπανός